Appendix A

Unit Dose Calculations

Appendix A

Unit Dose Calculations

Radioactive Source	Landfill 13,160 m Unit Dose (mrem/Ci)	Pond 13,069 m Unit Dose (mrem/Ci)	Radioactive Source	Landfill 13,160 m Unit Dose (mrem/Ci)	Pond 13,069 m Unit Dose (mrem/Ci)
Ac-225	9.98E-02	1.01E-01	Pa-234m	9.63E-18	1.13E-17
Ac-227	1.07E+01	1.08E+01	Pd-107	2.78E-04	2.81E-04
Ac-228	2.00E-01	2.02E-01	Pm-147	8.15E-04	8.22E-04
Ag-109m	1.38E-25	1.82E-25	Pr-144	9.61E-08	9.83E-08
Ag-110	6.35E-35	9.84E-35	Pu-236	1.46E+00	1.47E+00
Ag-110m	2.24E-02	2.26E-02	Pu-238	5.54E+00	5.59E+00
Am-241	9.18E+00	9.27E+00	Pu-239	5.98E+00	6.04E+00
Am-242	8.67E-04	8.76E-04	Pu-240	5.97E+00	6.03E+00
Am-242M	8.85E+00	8.93E+00	Pu-241	9.39E-02	9.48E-02
Am-243	9.18E+00	9.27E+00	Pu-242	5.68E+00	5.74E+00
C-14	1.23E-03	1.24E-03	Pu-244	5.64E+00	5.70E+00
Ce-144	8.89E-03	8.98E-03	Ra-223	1.55E-01	1.56E-01
Cm-243	6.15E+00	6.21E+00	Ra-225	9.28E-02	9.36E-02
Cm-244	4.85E+00	4.89E+00	Ra-226	3.38E-01	3.41E-01
Cm-245	9.49E+00	9.58E+00	Ra-228	1.40E-01	1.41E-01
Cm-246	9.38E+00	9.47E+00	Rb-87	8.53E-03	8.61E-03
Co-57	1.46E-03	1.48E-03	Ru-103	9.17E-04	9.25E-04
Co-58	2.67E-03	2.70E-03	Ru-106	1.35E-02	1.36E-02
Co-60	1.10E-01	1.11E-01	Sb-125	1.28E-02	1.30E-02
Cs-134	6.02E-02	6.08E-02	Sb-126	1.46E-03	1.47E-03
Cs-135	4.43E-03	4.47E-03	Sb-126m	1.19E-06	1.22E-06
Cs-137	1.16E-01	1.17E-01	Sm-147	1.22E+00	1.24E+00
Eu-152	1.05E-01	1.06E-01	Sm-151	5.58E-04	5.63E-04
Eu-154	8.49E-02	8.57E-02	Sn-126	4.07E-02	4.11E-02
Eu-155	3.74E-03	3.77E-03	Sr-90	7.57E-02	7.64E-02
Fr-221	5.42E-08	5.68E-08	Tc-99	1.56E-02	1.58E-02
H-3	2.23E-05	2.24E-05	Th-227	1.89E-01	1.90E-01
Hf-181	1.25E-03	1.26E-03	Th-228	4.05E+00	4.09E+00
Ho-166m	4.46E-01	4.50E-01	Th-229	1.13E+01	1.14E+01
I-129	1.64E-01	1.66E-01	Th-230	4.05E+00	4.09E+00

Radioactive Source	Landfill 13,160 m Unit Dose (mrem/Ci)	Pond 13,069 m Unit Dose (mrem/Ci)	Radioactive Source	Landfill 13,160 m Unit Dose (mrem/Ci)	Pond 13,069 m Unit Dose (mrem/Ci)
In-115	5.29E-02	5.34E-02	Th-231	1.52E-05	1.53E-05
K-40	8.67E-02	8.75E-02	Th-232	9.79E+00	9.88E+00
Kr-85	4.91E-08	4.95E-08	Th-234	1.46E-03	1.47E-03
Mn-54	7.00E-03	7.07E-03	U-232	8.03E+00	8.10E+00
Nb-93m	2.37E-03	2.39E-03	U-233	2.30E+00	2.32E+00
Nb-94	4.75E-01	4.79E-01	U-234	2.25E+00	2.27E+00
Nb-95	2.52E-03	2.55E-03	U-235	2.14E+00	2.16E+00
Np-237	8.39E+00	8.47E+00	U-236	2.13E+00	2.15E+00
Np-238	5.28E-04	5.33E-04	U-238	2.00E+00	2.02E+00
Np-239	5.55E-05	5.61E-05	U-240	3.57E-05	3.60E-05
Np-240	4.95E-06	5.03E-06	Zn-65	2.14E-02	2.16E-02
Np-240m	2.01E-08	2.09E-08	Zr-93	9.78E-04	9.87E-04
Pa-233	5.67E-04	5.72E-04	Zr-95	1.91E-03	1.92E-03
Pa-234	4.11E-05	4.15E-05			

Appendix B

K_d Values

Appendix B

K_d Values

Table B-1. Partition coefficients, K_d values, for sand similar to ICDF.[a]

	Preference							
	#1	#2	#3	#4	#5	#6		
Nuclide	EDF-ER-170[b]	OU 3-13 RI/BRA[c]	Track 1[d]	Sheppard and Thibault[e]	NCRP 123[f]	EPA 402-R-99-004A[g]	Selected K_d Value for Leachate (INEEL)	Notes
Ac	—	—	—	450	420	—	450	
Ag	—	90	90	90	90	—	90	
Al	—	250	—	—	—	—	250	
Am	340	340	340	1900	1900	—	340	
Ar	—	—	—	—	—	—	0	Gaseous element.
As	3	3	3	—	110	—	3	
At	—	—	—	—	—	—	0	This is a halogen with similar properties to iodine. (CRC 61st edition)
Au	—	—	—	—	30	—	30	
B	—	—	—	—	—	—	5	Chemically similar to carbon. (CRC 61st edition)
Ba	—	50	50	—	52	—	50	
Be	—	250	250	250	240	—	250	
Bi	—	—	100	100	120	—	100	
Bk	—	—	—	—	—	—	4000	Chemical similar to Cm based on valence states and actinide chemistry. (CRC 61st edition)
Br	—	—	15	15	14	—	15	
C	—	—	0	5	6.7	—	5	Assumed to not be gaseous.
Ca	—	—	5	5	8.9	—	5	
Cd	—	6	6	80	40	8	6	
Ce	—	—	500	500	500	—	500	
Cf	—	—	—	—	510	—	510	
Cl	—	0	—	—	1.7	—	0	
Cm	—	—	—	4000	4000	—	4000	
CN-	—	—	0	—	—	—	0	
Co	—	10	10	60	60	—	10	
Cr	—	1.2	1.2	70	30	70	30	Assumed to not be Cr+6.
Cs	500	500	500	280	270	30	500	

Table B-1. (continued).

	Preference							
	#1	#2	#3	#4	#5	#6		
Nuclide	EDF-ER-170[b]	OU 3-13 RI/BRA[c]	Track 1[d]	Sheppard and Thibault[e]	NCRP 123[f]	EPA 402-R-99-004A[g]	Selected K_d Value for Leachate (INEEL)	Notes
Cu	—	20	20	—	30	—	20	
Dy	—	—	—	—	—	—	240	Same as other rare earth elements.
Er	—	—	—	—	—	—	240	Chemistry similar to other rare earth elements.
Eu	—	340	—	—	240	—	340	
F	—	0	0	—	87	—	0	
Fe	—	—	220	220	160	—	220	
Fr	—	—	—	—	—	—	500	Chemical similar to cesium. (CRC 61[st] edition)
Ga	—	—	—	—	—	—	250	Chemically similar to aluminum and indium in relation to periodic table.
Gd	—	—	—	—	240	—	240	
Ge	—	—	—	—	—	—	35	Chemically similar to silicon and tin in relation to periodic table.
H	—	0	0	—	0	—	0	
He	—	—	—	—	—	—	0	Gaseous element.
Hf	—	—	—	450	—	—	450	
Hg	100	100	100	—	19	—	100	
Ho	—	—	—	250	240	—	250	
I	0	0	0	1	1	—	—	
In	—	—	—	—	390	—	390	
Ir	—	—	—	—	91	—	91	
K	—	15	15	15	18	—	15	
Kr	—	—	—	—	0	—	0	
La	—	—	—	—	1200	—	1200	
Li	—	—	—	—	—	—	15	Alkali metal element similar to potassium. (CRC 61[st] edition)
Lu	—	—	—	—	—	—	240	Chemistry similar to other rare earth elements.
Mg	—	—	—	—	—	—	5	Chemically similar to calcium.
Mn	—	50	50	50	50	—	50	
Mo	—	—	—	10	10	—	10	
N	—	0	—	—	—	—	0	Same movement as nitrate.
Na	—	—	—	—	76	—	76	
Nb	—	100	—	160	160	—	100	

Table B-1. (continued).

	Preference							
	#1	#2	#3	#4	#5	#6		
Nuclide	EDF-ER-170[b]	OU 3-13 RI/BRA[c]	Track 1[d]	Sheppard and Thibault[e]	NCRP 123[f]	EPA 402-R-99-004A[g]	Selected K_d Value for Leachate (INEEL)	Notes
Nd	—	—	—	—	240	—	240	
Ne	—	—	—	—	—	—	0	Gaseous element.
Ni	—	100	100	400	400	—	100	
Np	8	8	—	5	5	—	8	
O	—	—	—	—	—	—	0	Gaseous element.
Os	—	—	—	—	190	—	190	
P	—	—	—	5	8.9	—	5	
Pa	—	—	—	550	510	—	550	
Pb	100	—	100	270	270	710	100	
Pd	—	—	—	55	52	—	55	
Pm	—	—	—	—	240	—	240	
Po	—	—	—	150	150	—	150	
Pr	—	—	—	—	240	—	240	
Pt	—	—	—	—	—	—	55	Chemically similar to palladium in relation to periodic table.
Pu	140	22	22	550	550	80	140	
Ra	—	—	100	500	500	—	100	
Rb	—	—	—	55	52	—	55	
Re	—	—	—	10	14	—	10	
Rh	—	—	—	—	52	—	52	
Rn	—	—	—	—	0	0	0	
Ru	—	0		55	55	—	55	
S	—				14	—	14	
Sb	—	50	50	45	45	—	50	
Sc	—	—	—	—	310	—	310	
Se	—	4	4	150	140		4	
Si	—	—	—	35	—	—	35	
Sm	—	—	—	245	240	—	240	Chose most conservative.
Sn	—	—	—	130	130	—	130	
Sr	12	12	24	15	15	15	12	
Ta	—	—	—	220	—	—	220	
Tb	—	—	—	—	240	—	240	
Tc	0.2	0.2	—	0.1	0.1	—	0.2	

Table B-1. (continued).

Nuclide	Preference #1 EDF-ER-170[b]	#2 OU 3-13 RI/BRA[c]	#3 Track 1[d]	#4 Sheppard and Thibault[e]	#5 NCRP 123[f]	#6 EPA 402-R-99-004A[g]	Selected K_d Value for Leachate (INEEL)	Notes
Te	—	—	—	125	140	—	125	
Th	100	—	100	3200	3200	1700	100	
Ti	—	—	—	—	—	—	600	Chemically similar to zirconium in relation to periodic table.
Tl	—	100	—	—	390	—	100	
Tm	—	—	—	—	—	—	240	Chemistry similar to other rare earth elements.
U	6	6	6	35	15	63	6	
V	—	6	1000	—	—	—	6	
W	—	—	—	—	100	—	100	
Xe	—	—	—	—	0	—	0	
Y	—	—	—	170	190	—	170	
Yb	—	—	—	—	—	—	240	Chemistry similar to other rare earth elements.
Zn	—	—	16	200	200	—	16	
Zr	—	—	600	600	580	—	600	

Note: Dashes in the table indicate that no value is given in that document for the specific nuclide.

a. Doornbos, M. H., BBWI, personal communication with attached spreadsheet to B.D Preussner, BBWI, subject: "K_d Table," Attachment: "Kd values for INTEC fate and transport," May 15, 2001.

b. EDF-ER-170, 2000, "Screening Model Results of a Mixed Low-Level Waste Disposal Facility Proposed for the Idaho National Engineering and Environmental Laboratory," Rev. 0, Environmental Restoration Program, November 2000.

c. DOE-ID, 1997, *Comprehensive RI/FS for the Idaho Chemical Processing Plant OU 3-13 at the INEEL – Part A, RI/BRA Report,* DOE/ID-10534, Rev. 0, November 1997.

d. DOE-ID, 1992, *Track 1 Sites: Guidance for Assessing Low Probability Hazard Sites at the INEL,* Appendix G, DOE/ID-10340(92), Rev. 1, July 1992.

e. Sheppard, M. I., and D. H. Thibault, 1990, "Default Soil Solid/Liquid Partition Coefficients, K_ds, for Four Major Soil Types: A Compendium," *Health Physics,* Vol. 59, Number 4, pp 471–482.

f. NCRP, 1996, "Screening Models for Release of Radionuclides to Atmosphere, Surface Water, and Ground," NCRP Report No. 123 I, Table 4.1, National Council on Radiation Protection and Measurements, January 1996.

g. EPA, 1999, "Understanding Variation in Partition Coefficient Kd, Values," EPA 402-R-99-004A, U.S. Environmental Protection Agency, August 1999.

Appendix C

SSSTF NESHAP Evaluation

Appendix C

SSSTF NESHAP Evaluation

Summary

The SSSTF was evaluated as part of the 30% design using 40 CFR-61.96 to determine if an application for approval to construct was required. The source term was derived using 40 CFR 61 Appendix D. The source term was modeled and the effective dose equivalent was determined to be 0.006 mrem/yr. This is less than the 0.1 mrem/yr limit below which no application is required.

Since the preparation of the 30% design, further assessment of the waste streams has eliminated the majority of the wastes originally calculated to be managed at the SSSTF. Elimination of waste streams (and volumes) originally in the 30% design calculations will reduce the radioactivity being released. A new analysis is not required because it has been shown that if all of the original waste identified in the 30% design could be processed without exceeding the 0.1 mrem/yr limit then processing less activity will reduce the original source term. Therefore, the emissions from the SSSTF are not a permitting or monitoring concern.

Discussion

SSSTF Airborne Radionuclide Source Term and Doses (30% Design Evaluation)

The following assumptions were made in developing the airborne radionuclide releases from the SSSTF:

- Only wastes undergoing stabilization in SSSTF have potential for radiological emissions; soils going to ICDF without treatment are not considered in SSSTF source term.
- Handling/stabilizing soil represents a worst case from an emissions standpoint; bounds other SSSTF releases.
- For each release site, maximum radionuclide concentrations measured in soil are assumed for all soil from that release site (maximums are from EDF No. 1, *Waste Inventory Design Basis*).
- <u>All</u> waste being stabilized is treated as soil, i.e., total waste volume is assumed to be soil at maximum radionuclide concentrations.
- Release fraction of 1E-03 for particulate radionuclides assumed per 40 CFR 61, Appendix D (NESHAP Guidance).
- No cleanup of airborne releases from SSSTF is credited.
- Spreadsheet "Waste Schedule 9-27-00" used to allocate source terms by year (Table 1).
- Source term calculation:
    - <u>Total Ci radionuclide i in waste</u> = Vol waste (yd^3) x 0.765 m^3/yd^3 x 1×10^6 cc/m^3 x

      1.5 g/cc (soil density) x measured level of radionuclide i (pCi/g) x 1Ci/1×10^{12} pCi

$$\text{i Ci waste} = \left(\frac{\text{i pCi}}{\text{g soil}}\right)\left(\frac{\text{yd}^3}{\text{yr}}\right)\left(\frac{0.765\ \text{m}^3}{\text{yd}^3}\right)\left(\frac{1\times10^6\ \text{cc}}{\text{m}^3}\right)\left(\frac{1.5\ \text{g soil}}{\text{cc}}\right)\left(\frac{\text{Ci}}{1\times10^{12}\ \text{pCi}}\right)$$

- Release of radionuclide i (Ci) = Total Ci radionuclide i in waste x 1×10^{-3}

$$\text{i Ci released} = \left(\frac{\text{i Ci waste}}{1{,}000}\right)$$

- Doses modeled with CAP88 dispersion/dose code
  - Ground-level release
  - 10-year average meteorology from 10m level of NOAA's Grid 3 tower
    - Dose to maximally exposed individual at INEEL boundary, 13900 m SSW.

To determine if a point source requires monitoring the potential to emit radioactivity is calculated. The potential to emit is based on the discharge of the effluent stream that would result if all pollution control equipment did not exist, but the facilities operations were otherwise normal.

For INEEL NESHAP permitting purposes it has been decided that the MEI receptor location will be on the INEEL boundary rather than at the location determined for the annual NESHAP report. This is because the actual MEI has the potential to be different from year to year. The worst case MEI at the site boundary will bound any actual location.

The MEI location is determined by screening calculations using CAP88. Doses are calculated for INEEL boundary locations that are closest within each of the 16 compass direction sectors. For facilities on the south end of the INEEL, the MEI is within the south southwest sector. This is because the predominate nocturnal air movement is from the north northeast and the ICDF complex is much closer to the southern INEEL boundary.

For purposes of NESHAP multiple year average meteorology is used. The latest long term average wind files from National Oceanic and Atmospheric Administration are 10 year averages from 1987 through 1996. The NOAA provided 10 year average annual rainfall is 20.8 cm and the temperature is 279 K (6°C).

Table 1 shows that the maximum dose for any year from SSSTF using Appendix D would be 6.0×10^{-5} mrem/yr. This is less than the PTC limit of 0.1 mrem/yr, therefore, no approval to construct is required.

The potential to emit is also shown in Table 1 to be 6.0×10^{-3} mrem which is less than 0.1 mrem/yr. This means that the point source from SSSTF does not require continuous monitoring.

Table 1. SSSTF waste stabilization worst case doses to the MEI.

Year	Release Site	Volume (yd^3)	"Potential to emit" Dose without HEPAs (memrem/yr)	"Appendix D" Dose with HEPAs (mrem/yr)
2001	CFA-04*	800	1.1×10^{-4}	1.1×10^{-6}
2003	Borax-01	11,110	5.2×10^{-3}	5.2×10^{-5}
2004	ARA-12	1,000	6.0×10^{-3}	6.0×10^{-5}
	ARA-25	36		
	WRRTF-1	20,070		
	CPP-92*	1,370		
	CPP-98*	250		
	CPP-99*	126		
2005	ARA-12	1,000	7.1×10^{-5}	7.1×10^{-7}
	ARA-25	36		

* Note: The waste marked with an (*) will be treated in the SSSTF. The remaining waste streams will not go to the SSSTF for processing.

Conclusion

The SSSTF does not require an approval to construct per 40 CFR 61.96 nor does it need monitoring per 40 CFR 61.93 (b) (4).

This determination was initially made based on the SSSTF NESHAP evaluation during 30% design. Since that time, most to the waste streams have been removed from being processed in the SSSTF. This will reduce the radioactive emissions. Therefore, with less emissions the SSSTF will still not require an approval to construct or monitoring.